Performance Improvement Of Low Power LED Units

Hend Abd El-monem Salama

Abstract: Currently, electronic loads have been expanded in different sectors of societies that make the researchers do a great effort to discover the problems of the non-linearity on the electric power network and provides several solutions to overcome and eliminate their effects. Low power LED units are nonlinear loads that have high potential problems divided into poor power factor and current harmonic distortion and used in several applications. This paper presents two practical techniques which include number of different types of low power LEDs and one unit of CFL. The list of selected units are engaged in certain groups to be tested. A single tuned passive filter is used to enhance the performance of each units group and the results are analyzed and concluded.

Index Terms: Low power LED units, Tested units, improvement performance group, Power factor (PF), total harmonic distortion (THD).

1 Introduction

POWER document is a template for Microsoft Word quality requirements of LED units have significant parameters affecting directly on the power system distribution network. Harmonic distortion of voltage & current waveforms along with power factor are interdependent parameters provided by nonlinear loads. LED units is one of the significant nonlinear load since it has been widely used in several applications like residential, commercial and industrial applications. Most of low power LEDs units have poor performance defined by power factor (PF) with high percent of total harmonic distortion of current waveforms (THD) that may cause serious problems in electric power system such as overheating and losses [1],[2]. When fluorescent lamp and LED unit are working together by using fluorescent electronic ballast, better performance is achievable [3]. Modern technology drivers such as boost and buck-boost converters are connected to LED units to reduce THD to be less than 2% and exceed power factor to reach over 98% [4]. Converters enhance LED's performance but it is highly costs for wide applications. Also, adding capacitors randomly to LED circuits may increase the average power factor reducing total harmonic distortion but it is expensive costing for wide applications and may cause noise, over current and overheating in electric power system [5]. Some successful thesis set up groups of Compact Fluorescent Lamps (CFLs) and LEDs units or sets of several wattage of LED units which operate together and achieve outstanding performance for the units group [6], [7]. Passive filters and active filters are being used and the most efficient filter is called tuned passive filters which have been applied for nonlinear loads in general. All obtained results of previous thesis are in accordance with IEEE 519 – 1992 standards [8], [9], [10]. Performance quality of low power LED units have been investigated in few thesis. This paper presents two practical techniques which are called optimum technique and permanent technique. The two techniques are established to test the groups of low power lighting units. A list of different types of low power LED units and one unit of CFL are merged in groups and used in the proposed techniques.

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2 Case Study

List of units are composed of seven different types of low power LED units and one unit of CFL used in the two technique. Power fluke analyzer measures PF and THD of tested groups. A distributor box is designed to feed group of units shunted with the power supply. The two techniques use the same list of units merged in several groups that are A, B, C, D, F and G. Simple tuned passive filter is designed according to estimation of reactive power needed for target PF. Then, filter is used to test the group performance

2.1 Optimum Technique

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Experimental Set-up

- Nominal and technical data of tested units such as flowing current, PF, THD, VA and VAR (Volt Ampere Reactive) are listed in table 1. According to table 1, best performance units are unit 4 and unit 6 which are defined by modified units.
- Some of used LED units and CFL unit have poor performance which have PF less than 0.6 and so higher percent of THD that exceeds than that IEC6-1000-3-3 standard, Class C. Testing circuit is built as shown in Fig. 1.
- The list of tested units are merged in groups called A, B, C, D, E, F, G and H. Performance parameters of these groups represented by PF and THD are measured and recorded in table 2.

Fig. 1. *Testing circuit of optimum technique.*

TABLE 1 *technical data of selected tested lighting units*

No.	Type-Code	Nominal W	Measured Current, mA	Measured PF	Measured THD %	Measured VA	Measured VAR
Unit 1	SC- C000 136- 3W	3	32	0.35	90	8	8
Unit 2	Spot - MR16	3	37	0.51	87	8	7
Unit 3	Spot - MR16	6	32	0.52	83	7	6
Unit 4	Bulb T-L4B42- 6W	6	29	0.75	14.1	7	5
Unit 5	Bulb, E14-Guarrantee 20160607	4.8	32	0.32	77.9	2	2
Unit 6	A65- transparent	9	39	0.89	13.0	8	5
Unit 7	E27-865779	8.7	65	0.36	76.4	4	4
Unit 8	Tornado, CFL	12	29	0.49	78.7	11	10

TABLE 2 *power factor and total harmonic distortion of tested units*

Group	A	B	C	D	E	F	G	H
Unit 1	•							
Unit 2	•	•	•	•	•	•	•	•
Unit 3	•		•	•	•	•	•	•
Unit 4			•	•	•	•	•	•
Unit 5	•				•	•	•	•
Unit 6		•		•	•			•
Unit 7	•		•		•	•	•	•
Unit 8	•						•	•
PF	0.59	0.78	0.73	0.74	0.72	0.68	0.76	0.74
THD %	77	77.8	54.9	52.7	54.6	63.5	52	56
VAR	490	450	200	190	230	290	330	440

Eight experiments are completed and the results are analyzed and evaluated as following:

1. It is obvious that group H provides the best performance group where it integrates all tested units except unit 1, implemented PF equals 0.74 and THD is 56.2 % as indicated in Fig 2.
2. PF and THD of group A is represented in Fig 3 which is the lowest performance group. This is due to the units of the group have poor performance especially unit 1 that has inverted dc current waveform with higher percentage THD and poor PF as indicated in the Appendix [1].

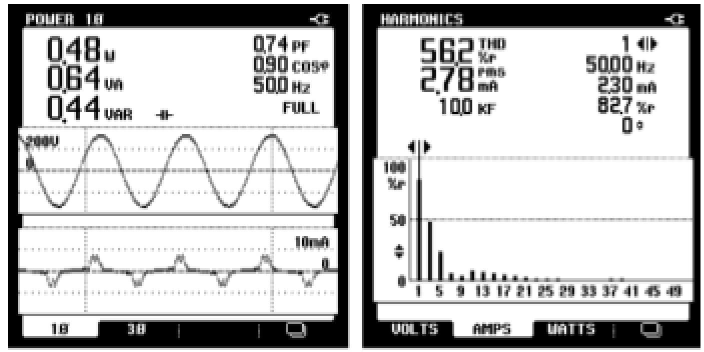

Fig. 2. *Performance of group H of optimum technique.*

3. If CFL unit is added in the group, it assists in improving the performance group [11]. Higher performance of group is achieved when number of tested units is few or modified unit is added to the group like group B.
4. Observed that the performance of the group depends on the number of modified units added to the group in accordance to number of poor units like groups; C, D, E and F regardless their wattages. Groups C and D have the same number of tested units but their performance are different because group C has one modified unit while group D includes two modified units.
5. Since CFL unit is one unit of group G, it has a positive effect for improving the group performance when compared with group F.

2.2 Permanent Technique

Filter circuit is composed of series inductance and parallel capacitor which tuned the third harmonic current of group units. It is the most effective topology filter added to the inputs of units group to achieve the group performance. The capacitance and inductance are estimated through the selection of the worst performance group conducted in the first technique and then the reactive power needed for the improved proposed PF is calculated as explained below.

1. Filter Circuit Design

Group A has poor performance since its PF is 0.59 with THD equals 77%, that it is required to be corrected. Target PF will 0.98 and so, the inductance and capacitance ratings of filter design is estimated as follows [2], [12], [13]

$$Q_c = P\{\tan(\cos^{-1}\varphi_{actual}) - \tan(\cos^{-1}\varphi_{target})\} \quad (1)$$

Where,

Q_c is the reactive power required to achieve the net PF of the group to be 0.98.

P is the measured consumed power of the group

$\cos^{-1}\varphi_{actual}$ is the measured worst PF of the group.

$\cos^{-1}\varphi_{target}$ is the modified PF of the group.

From equation (1),

$$Q_c = 350\ (\tan 53.83° - \tan 11.48°) = 407.7\ VAR \quad (2)$$

The reactance capacitance for the first harmonic order and the third harmonic order are:

$$X_{C1} = \frac{V^2}{VAR} = 135.57\ \Omega \quad (3)$$

$$X_{Lh} = X_{Ch}, \qquad X_{L3} = X_{C3}$$

$$X_{L1} = (1/h)\, X_L \times h \qquad X_{L3} = 15.06\ \Omega$$

$$\therefore\ C = \frac{1}{2\pi f\, x_C} = 23.5\ \mu F \qquad (4)$$

The filter must be tuned at the third order harmonic which has higher percent of current harmonic distortion. Then,

$$\therefore\ L = \frac{x_L}{2\pi f} = 48\ mH \qquad (5)$$

From equation (4) and equation (5), the filter circuit is designed and connected to input of tested units' circuits of group A as shown in Fig. 4. Filter can be connected to Group F and group H to define their performance.

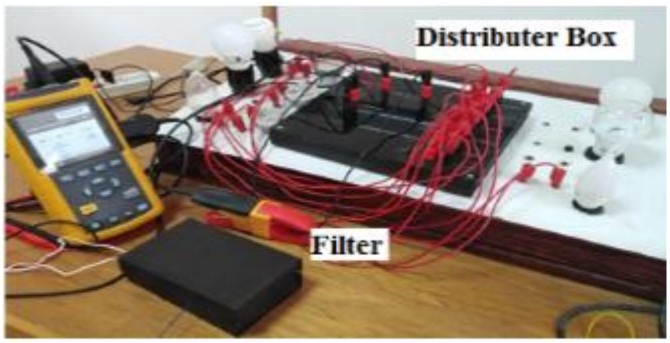

Fig. 4. *Permanent technique circuit.*

2. Results Analysis

Permanent technique achieves performance improvement of group A where PF becomes 0.8 and so THD is reduced to be 49.2 % as shown in Fig. 5. Reactive power required for reactor capacitor based on the proposed PF is 0.98 but when the circuit is tested, Fluke analyzed records new PF equals 0.8. This may be due to the expected error of filter components, LEDs' drives problems and the used number of the tested units.

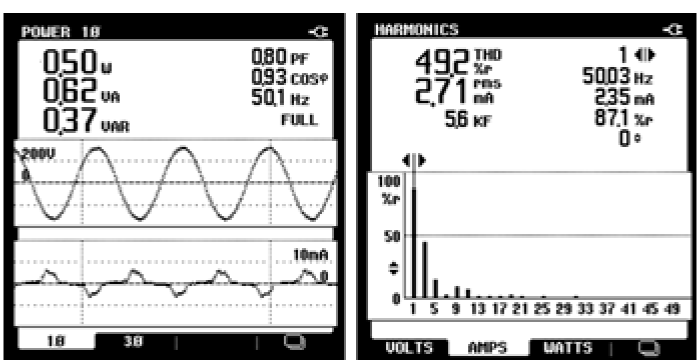

Fig. 5 *Performance Improvement of group A of permanent technique*

When the filter is connected to groups, F and H have new performances represented in figures 6 and 7 respectively. Results showed that performance improvement of the group is based on number of tested units in the group. Accordingly, group F has been implemented highest performance where group PF becomes 0.81 reducing THD to be 45.6%.

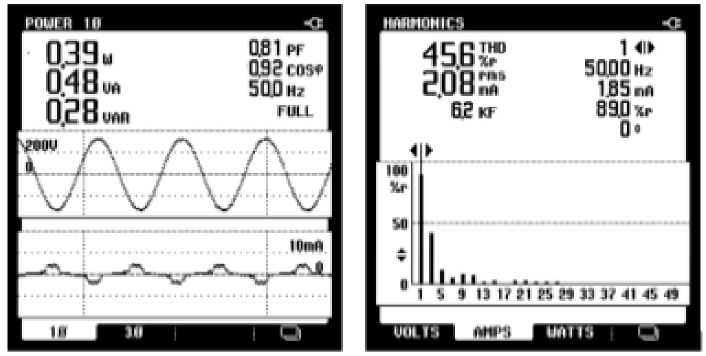

Fig. 6. *Performance Improvement of group F of permanent technique.*

3 CONCLUSION

This paper represent practical solutions for power quality problems of low power LED units. Improvement of PF and lower THD of the group have been achieved after study the performance of each unit existed in the group. This strategy is qualified for groups of LED units or CFL units merged with LED units. Simple and cheapest tuned passive filter can be implemented to develop the group units' performance. Usage of this filter can be extended to be utilized in residential sector which has large consumers with various designs and ratings to suit all units used interiorly. To avoid the power quality problems of LED's units productions on the long run, manufacturers must review low power LEDs units especially LEDs drives components to avoid poor PF and higher THD that have serious problems on the electric network. Technical surveillance must evaluate LEDs units exist in local markets. Nonlinear loads must be connected to special lines prepared from the electrical grid.

Appendix

App Fig. 1 indicates high percentage of THD of tested unit1 and the inverted dc current waveform.

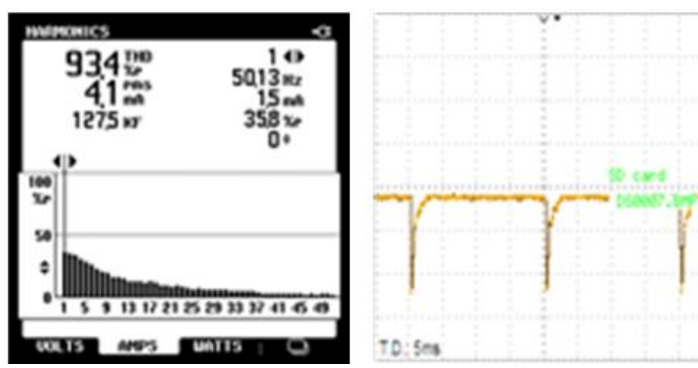

Fig. 1. *Total harmonic distortion and distorted current waveform of tested unit 1*

Acknowledgment

The authors wish to thank Engineer Ahmed Fawzy for helping to finish the practical part of this paper.

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